From “Nuts & Bolts” to “Bits & Bytes”-
The Evolution of Taiwan ICT in a Global Knowledge-based Economy

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1. Introduction

1.1 Motivation and Objectives

As we have entered the information age and developed a digital economy, with the rapid development of satellite communications, the universal penetration of the internet, and the emergence of intelligent industries, ‘speed’ and ‘innovation’ have become the main factors spurring industrial development. Taiwan, with its universal education, highly educated citizenry, high-quality workforce, and facility in cultivating technical personnel, is very well positioned for the development of knowledge-intensive high-technology industries. This is where Taiwan’s comparative advantage lies.

Industry output by value of the ICT hardware sector and IT software sector respectively was US$684.1 and 49.4 hundred million in 2004. The proportion of ICT expenditure to GDP was then 1.7%. And according to a survey conducted by FIND, the number of internet subscribers (internet access accounts) in Taiwan reached 9.98 million as of December 2004. In 2004, 61% of households in Taiwan were connected to the internet, and 81% of Taiwan enterprises had internet access. The bandwidth used for international internet connection in Taiwan exceeded 70 Gbps; there were over 5 million mobile internet subscribers in Taiwan; and the Taiwan government offered 847 government services online as of the end of 2004 (FIND website, 2006).

In contrast to other countries, the most special aspect of Taiwan lies in its deep historical origins and geo-relations with Mainland China, which causes both sides to have an inseparable relation in economic development, even though they have opposing stances in politics at the present stage. All these complex factors help shape the intricate appearance of the development process in the formidable Taiwan ICT industry.

Taiwan’s ICT policy developments have had fruitful outcomes. In June 2002, the Taiwan government proposed the "Two-Trillion and Twin-Star" programme to establish digital content as one of the industries with an annual production value of over NT$1 trillion. Facing the changes of the digital world, the Taiwan government has actively worked to promote digitization through a number of initiatives in recent years to improve the nation’s IT proficiency and the competitiveness of domestic IT industries. In May 2002, NICI and other government agencies worked together to launch the “e-Taiwan Program” as a part of the Challenge 2008 Program. With the need for a sound

e-business framework and application standards, DOIT of MOEA commissioned ACI of III[1] to undertake long-term research and promotion work with regard to the "E-Business Standard Research Plan". Besides, in order to continually strengthen the enterprises' digital capacities, projects A/B/C/D/E aim to create an e-business supply chain system, lay the foundations for a new business model where "orders are received in Taiwan, production can take place anywhere in the world". In addition, the Taiwan government proposed the "M-Taiwan Program" to promote a ubiquitous network and e-services in Taiwan with a budget of NT$37 billion over five years.

1.2 Methodology and Analytical Framework for the Taiwan Study

This study describes the development and transition of the whole knowledge-based economic society in Taiwan, based on an analysis of the structure of the National Innovation System (NIS) from the viewpoint of coevolution, and explains the efforts Taiwanese government authorities made in the development of high-tech or sunrise industries (especially ICTs) from both the supply side and demand side of industrial policy; especially when facing the tendency toward internationalization and the abrupt emergence of Mainland China. Because Taiwan is newly industrialized, its industry depended on foreign direct investment in its early days, subcontract production modes (e.g. OEM), before establishing its own innovative competence. In Section 2 we start with sketching Taiwan's economic growth. Section 3 analyses the changes in the Taiwan NIS. Section 4 devoted to the major industrial policies and governance in Taiwan. Section 5 and 6 addressed the role played by ICT and its policy implications. The paper finishes with the offshore development of Taiwan's ICT/IT in Mainland China in Section 7.

2. Growth Drivers Since 1990

2.1 Industrial structure change

To understand the development of the national industrial system, it will be most insightful to break down Taiwan's economic development into three stages as in Table 1 (Yu, 1999: 6-22).

Table 1

Economic Growth and Structural Change in Taiwan

Period	Economic growth rate (%)	Agriculture (%)		Industry (%)		Services (%)	
		GDP percentage share	Sectoral growth rate	GDP percentage share	Sectoral growth rate	GDP percentage share	Sectoral growth rate
1952-1980 (68SNA)	9.21	19.68	4.24	31.34	12.39	49.00	9.08
1982-1995 (68SNA)	7.86	5.01	1.33	40.17	6.18	54.82	9.33
1995-2004 (93SNA)	4.5	2.13	-0.67	29.09	3.77	68.77	5.01

Source: ROC National Income (in Chinese). Taipei: Directorate General of Budget, Accounting and Statistics, Executive Yuan, R.O.C.

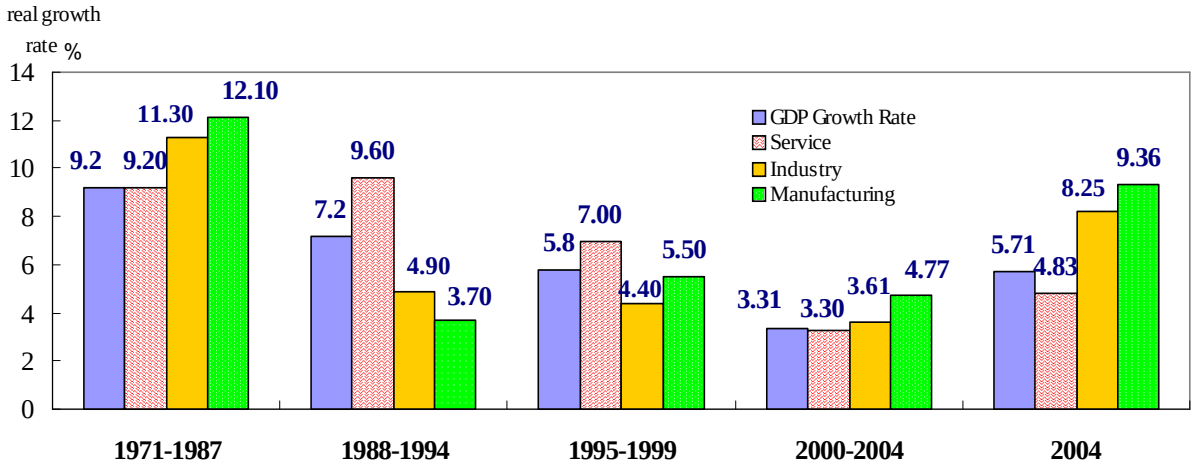
[1] See below for many of these acronyms as well as further details.

For many years the government has encouraged industry to engage in technology development. For instance, every year the Ministry of Economic Affairs (MOEA) provides funding to non-profit research institutions for the development and transfer to the private sector of "critical, common, and forward-looking" technologies, and allows public and private enterprises to participate in technological research projects. In order to encourage and support industrial R&D, the NSC has promoted the *"Research and Development of Key Parts, Components and Products Program"* within the Hsinchu Science-based Industrial Park, and also regularly provides market information and technical assistance in order to reduce market risk and stimulate industry's willingness to engage in R&D work.

2.2 Trends in productivity

As to the cause of inferior performance of Taiwan's labor productivity is associated with the industrial structure and business operation mode. Taiwan's industrial structure is largely concentrated on so-called ICT domain in the "high-tech industry", although in the past due to the fast growth of ICT industry, Taiwan's overall economic growth was supported. However, recent years IT hardware industry is facing the threat of the late coming countries, the quick drop of product prices and the constrain of large international companies, thus, the overall ICT industrial added value and gross profit are gradually reduced. Additionally, the low growth of service sectors and the low growth rate of labor productivity in recent years, which is even lower than the growth rate of the manufacturing labor productivity (see Figure 1), have caused the insufficient growth of Taiwan's overall labor productivity (Lin et al., 2005).

Figure 1:
Average growth rate by sector in Taiwan, 1971-2004



Source: DGBAS, National Income in Taiwan, 1971-2004.

2.3 Trends of Venture Capital and FDI

At the initial stages as Taiwan started to develop in the high-tech field, there was no venture capital business. Thus, the government established the Development Fund of Executive Yuan in 1973 to invest in venture capital and coordinated Chiang Tung Bank to provide refinance for venture capital. However, the preliminarily introduced venture capital created only a few successful cases that led the industrial development. The first venture capital company was established in 1984 after reinvestment by Acer. The number of venture capital companies increased slightly to the early 1990s (Wu et al., 2002). The number of venture capital firms in Taiwan then grew to 259 in 2004. Their accumulated capital increased from NT$200 million in 1984 to NT$ 184.5 billion in 2004, growing over 922 times within two decades.

The investment in Electronic & Electrical Appliances by overseas Chinese and foreign companies in Taiwan has had a tendency to rise gradually in recent decades. The year 2000 was a watershed, reflecting the first rotation of political party in Taiwan, and when FDI attained high levels. However, the political and economic situation after the political change (such as political infighting among parties, the economic emergence of Mainland China and India, etc.) was not as good as anticipated; and the cases and amounts of overseas Chinese and FDI have reduced year by year after 2001. In 2004 the total of *approved cases* dropped to the minimum since 2000 but increased considerably in amounts. This phenomenon was mainly because the government opened up an increasing range of sectors to foreign participation. This was particularly so in ICT, where there were changes to foreign investment regulations, particularly in foreign ownership levels in the telecommunications sector.

3. The Transformations of Taiwan's NIS

The Ministry of Economic Affairs (MOEA) is chiefly responsible for industrial technology applications research, and it transfers the results of research to the corporate sector for product development and commercialization via technical assistance, information sharing, and manpower training. To accomplish these goals, the MOEA relies on its own subordinate research organizations, the research departments of state-owned enterprises, and research organizations hired on a case-by-case basis. Industrial technology development work is conducted primarily via in-house R&D and secondarily via technology acquisition. The MOEA is working to strengthen interaction between industry, government, universities, and research institutions as a means of promoting technological upgrading throughout the industrial sector.

3.1 Trends in R&D Input

According to the annual Survey of National Science and Technology Activity, total public and private R&D expenditures amounted to NT$197.6 billion, or 1.94% of GNP in 2000, and NT$ 260.9 billion, or 2.34% of GNP in 2004. Furthermore, the nation's total R&D spending as a proportion of GDP remained at an average around 2.2% during these five recent years. R&D

expenditure as a percentage of GNP showed a gradual increase during the years from 1996 to 2004, although the growth rate of R&D expenditures declined sharply in 2000. However, the annual average growth rates of these expenditures are only 6.5% in the five most recent years.

Of overall national R&D spending of NT$260.85 billion in 2004, government agencies contributed NT$88.47 billion (33.9%), business enterprise NT$168.1 billion (64.4%), higher education NT$3.1 billion (1.2%), private non-profit organizations NT$1.1 billion (0.4%), and foreign institutions just NT$60 million (0.0%). As described, 64.4% of R&D funds came from enterprise in 2004. The proportion of enterprise R&D funds has tended to fall, which differs from the increasing tendency in advanced countries, and Taiwan even lacks overseas R&D investment (certain countries get 10% from overseas R&D capital). Similarly, according to the performing of R&D, the proportion by enterprises also has a tendency to fall year by year.

3.2 Education System and Human Capital

Taiwan had a total of 162 higher education establishments in 2005 School Year (from 2005/8-2006/7), 89 of which were universities. The student population of higher education for the same year was 938,648 students, 449,695 of whom belonged to the science and technology field, including 2,165 doctoral students and 42,334 masters students (Ministry of Education website: www.edu.tw, 2006). Compared with other nations, Taiwan has a higher registration ratio, with education and training in accord with national competitiveness requirements (Tzeng and Lee, 2001). This advanced educational achievement has been one of the primary factors in the vigorous development of the information industry.

An overview of the Taiwan educational system reveals that, in 2004, the government allotted 39.0% of its budget to the higher education. Public education enrolment rates reached 99.2% in the 2004 School Year, an achievement that compares favourably with other nations. Concerning the S&T indicators, Taiwan is rich in human resources. The number of researchers both per ten thousand of population and per ten thousand of the labour force has constantly increased over the preceding four years up to 2004 (Table 2).

Table 2

Numbers of Taiwanese researchers 1996-2004

Item / Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
Numbers of researchers (persons)	53754	56419	62586	67165	69525	73239	80999	85166	91490
Researchers/ R&D personnel (%)	NA	NA	NA	49.8%	50.5%	52.9%	53.9%	54.2%	54.3%
Researchers per 1000 population	2.5	2.6	2.9	3.0	3.1	3.3	3.6	3.8	4.0
Researchers per 1000 labour force	5.8	6.0	6.6	7.0	7.1	7.4	8.1	8.5	8.9

Data Source: Indicators of Science and Technology (Table 1-19 & 1-22), Republic of China, 2005

R&D personnel includes researchers, technicians, and supporting personnel. A total of 168,524

people were engaged in R&D work in 2004, and maintained an increasing trend over the preceding years. The total for 2004 included 91,490 researchers (54.3%), 59,583 technicians (35.4%), and 17,451 supporting personnel (10.4%). In terms of the distribution of researchers, 50,795 (47.3%) worked in Business Enterprise, 17,020 (50.4%), in the Government sector, and 22,781 (87.7%) in Higher education. Among these researchers, 23,306 (25.47%) held PhD degrees, and 38,912 (42.53%) Masters degrees. Similarly, the percentage of researchers with Masters and PhD degrees has also increased. The proportion of researchers among all R&D manpower has hovered around 56.3% over the past 10 years.

3.3 Patents and Publications

In Taiwan, basic research is chiefly conducted at the Academia Sinica, the national laboratories, various research centres, and university departments and graduate schools. The number of academic papers published is a direct indicator of basic research. The number of Taiwan's papers cited in the SCI database has increased every year. In 2004, there were 14,989 articles cited by Taiwan's authors in the SCI database, ranking at 19 in the world. Outside of universities and colleges, most of Taiwan's engineering and applied research is conducted at the Industrial Technology Research Institute (ITRI) and other public or non-profit research institutes (such as III for ICT). Over the past decade, an excellent research record has been achieved in such areas as electronics, information, communications, materials science, biology, agriculture, and food technology. There are 10,983 papers by Taiwan's authors in the EI database in 2004, ranking 11 in the world.

Another tangible result of research on science and technology has been the number of patents granted. Of the patents approved in 2004, 68% were by Chinese nationals and 32% by foreign nationals. This represents a substantial increase in the number filed by Chinese Nationals (Table 3).

Table 3
Domestic patents applied for and granted, 2001-2004

Item	Patents applied for			Patents granted		
	Total	Compatriot	Foreigner	Total	Compatriot	Foreigner
2001	67,860	40,210	27,650	53,789	32,310	21,479
2002	61,402	35,926	25,476	45,042	24,846	20,196
2003	65,742	39,663	26,079	53,034	30,955	22,079
2004	72,082	43,020	29,062	49,610	33,517	16,093

Source: Indicators of Science and Technology (Table 7-2), Republic of China, 2005

As for innovation patents, in 2004, there were 41,919 invention patent applications, of which 20,454 were approved. The number of patents granted in the US to assignees in Taiwan has increased rapidly, as have patents granted in Taiwan, although a large share of the patents in Taiwan is granted to foreigners. Table 4 shows indicators of research output of the period 2000-2004 (NSC,

2005:33-34).

Table 4

Patents 2000-2004

Item/Year	2000	2001	2002	2003	2004
Invention patents applied	28,451	33,392	31,616	35,823	41,919
Compatriot	6,830	9,170	9,638	13,049	16,747
Foreigner	21,621	24,222	21,978	22,774	25,172
Invention Patents granted	15,657	24,429	23,036	25,134	20,454
Compatriot	3,834	6,477	5,683	6,399	7,521
Foreigner	11,823	17,952	17,353	18,735	12,933
Patents granted in U.S.P.O.	4,667	5,371	5,431	5,298	5,938

Source: 1. Indicators of Science and Technology (Table 7-3, 12), Republic of China, 2005;

2. Taiwan Intellectual Property Office, TIPO website (2006)

4. Major Industrial Policies and Governance

4.1 Existing Industrial Policies

4.1.1 Tax Credits for R&D and Personnel Training

The MOEA is chiefly responsible for industrial technology research and its application. Apart from the MOEA's directly subordinate research units, the R&D department of state-owned enterprises and independent research institutes undertaking commissioned projects are also engaged in industrial R&D and technology transfer. Research institutes are employing technology acquisition, joint research, foreign direct investments and strategic alliances to interact with foreign companies, and research institutes as mechanisms to accelerate the industry's technological development. In addition, the government relies on administrative measures like subsidies, matching grants and investment tax incentives to encourage industry to engage in R&D activities.

4.1.2 Small Business Innovation Research

In accordance with the Knowledge Economics Development Act, the Department of Industrial Technology (DoIT) of Ministry of Economic Affairs (MOEA) launched Taiwan's SBIR promoting program, mostly referring to the US version of the SBIR, in Nov. 1998, in order to enhance the private sector's R&D competitiveness through promoting technological innovation and utilizing Information Technology on one side, and providing tax incentives and a subsidy of up to half of the cost of development and matching funds to resolve market failures and uncertainties of technology development on the other side.

The types of research encouraged by this programme include: 1) Developing a brand new idea, concept or new technology; 2) Applying an existing technology to a new application; 3) Applying a new technology or business model to an existing application; 4) Improving an existing technology

or product upon various aspects. By 2010, the SBIR promoting programme may assist in achieving the nationwide goal of Taiwan's R&D rising to 3% of GDP; and private sector R&D increases up to 60%, including 70% from knowledge-based industries.

4.1.3 Technology Development Programs

The Department of Industrial Technology (DoIT) is Taiwan's science and technology development flagship. Its primary mission is to promote industrial technology development to help create new national industries and help upgrade Taiwan's existing industries. Therefore, in cooperation with the Executive Yuan's promotion of the "scientific and technical development scheme", the government began to implement "the given-case program of MOEA scientific and technological research development" in 1979 (TDP for short). The DoIT takes charge of examining and allocating the subvention funds as the main overall promotion unit of scientific and technological given cases. In the initial stage of planning, the contracted research institution (TDP-contracted Research Institutes for short) is authorized to assist in industrial innovation, introduce each perspective, critical and compatible technology, and to bring about the cooperation between manufacturing and studying in order to help industries upgrade and change their type, strengthen their innovative R&D abilities, and increase their international competitiveness. To sum up, TDP-contracted Research Institutes are to adjust domestic industries to R&D innovation and prospective technology. On the contrary, the non-profit research institutes, involving DoIT contracts with the private sector and academic organizations respectively, carry out and develop basic and pioneer technologies that are then licensed to Taiwan's industries.

Table 5

TDP expenditures 2001-04

Fields of R&D	2001	2002	2003	2004
Telecom & Optoelectronics		37.48 (23.63%)	35.73 (25.37%)	34.85 (19.26%)
Machinery & Aerospace		30.62 (19.3%)	26.10 (18.54%)	26.44 (14.61%)
Materials & Chemicals		22.86 (14.41%)	26.25 (18.64%)	26.85 (14.84%)
Biomedical		14.11 (8.89%)	18.14 (12.88%)	18.23 (10.07%)
Pioneer Innovation program		32.52 (20.50%)	34.58 (24.56%)	19.81 (10.95%)
Others				17.04 (9.42%)
TDP for Corporation	135.64 (89.4%)	137.59 (86.73%)	140.81 (81.93%)	143.22 (79.14%)
TDP for Private Sector	16.08 (10.6%)	19.55 (12.32%)	27.35 (15.91%)	30.82 (17.03%)
TDP for Academia	0 (0%)	1.5 (0.95%)	3.72(2.16%)	6.94 (3.83%)
Total	151.73	158.64	171.88	180.98

Unit: NT$ million
Source: DoIT/MOEA (2005)

4.2 Major new policies

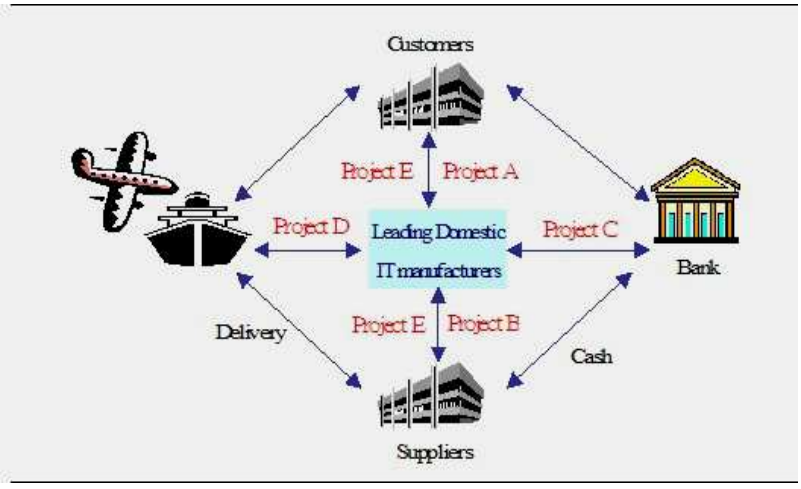
The Executive Yuan's current main tasks of policy implementation are to speed up the execution of major national development projects and to advance toward the goals set out in the Challenge 2008 Six-Year National Development Plan.

4.2.1 Supply side

4.2.1.1 ABCDE program (FIND, 2004)

Recognizing the importance of information technology towards the upgrading of Taiwan's industrial competitiveness, in June 1999 the Executive Yuan expanded its existing industrial automation project into a new **"Industrial Automation and Electronic Business: iAeB Program"**. While continuing to promote automation in production, warehousing, transportation and sales, the Ministry of Economic Affairs (MOEA) was instructed to give priority to the establishment of B2B (Business to Business) e-commerce systems, in order to build model e-business systems for both the supply chain and the demand chain. In 1999 the Department of Industrial Technology (DOIT) of the MOEA formulated and began implementation of two pilot projects for promoting e-business in the IT sector – Projects A and B. After implementation of Projects A and B had been completed, in 2001 the MOEA began implementation of Projects C, D and E as a continuation of Projects A and B. The aim of these new projects was to ensure the provision of e-business services covering payment, accounts receivable management, on-line financing, global inventory management, delivery tracking and collaborative design services in order to maintain the competitive advantage of Taiwanese industry and meet industry's evolving needs. The existing e-business supply chain system would be used as the foundation for further integration of cashflow, delivery systems and engineering collaboration, with the aim of strengthening the global logistics management capability of Taiwanese industry and its competitiveness in international markets (Figure 2).

Figure 2
Relationship between Projects A,B,C,D,E



Source: IT Applications Promotion Project, III / sponsored by DOIT, MOEA

4.2.1.2 Overview of industrial clusters in Taiwan

Taiwan has over 80 industrial parks spread throughout the island on all coasts, covering 11,000 hectares of land. Industrial parks have been the cornerstone of Taiwan's industrial development since their creation in the 1970s, and are a foundation of the island's economic success. Under the guidance of the Industrial Development Bureau (IDB), Taiwan's industrial parks has expanded to include science parks and parks that emphasize manufacturing support for high-tech industries.

In addition to industrial parks, there are also Economic Processing Zones (EPZs). These were initiated in the late 1950s and 1960s to set up export processing zones in Taiwan. The government established the first export processing zone in Taiwan, the Kaohsiung Export Processing Zone (KEPZ) in 1966. At the time, the government was facing financial difficulties, there was a shortage of foreign reserves, population was increasing, and unemployment rates were high, so there was an urgent need for the government to develop industries for export. At the same time, manufacturing industries in other industrialized countries were beginning to move overseas. A high-efficiency, free, special zone was needed facilitate export processing. EPZs have played a vital role in Taiwan's economic development and made outstanding contributions to the accumulation of foreign exchange and the introduction of new technologies.

Taiwan's science parks have the goals of attracting high-tech industries and manpower, encouraging domestic technological innovation, promoting industrial upgrading, balancing regional development, and achieving nationwide economic growth. The Hsinchu Science Park is a hotbed of the semiconductor and information industries; the Central Taiwan Science Park specializes in nanotechnology-based optoelectronics, aerospace, and precision machinery; and the Southern Taiwan Science Park is a stronghold of the optoelectronics industry. This science park system conforms to the government's industrial development maxim of ***"ICs in the north, nanotechnology in the centre, and optoelectronics in the south"***, and it fosters the emergence of dominant core industries. The objectives of science-based industrial parks are (a) to establish a base from which to develop high-tech industries, and (b) to cater exclusively to the needs of high-tech development, utilizing resources from industry, government, and academia to create an innovative environment that smoothly integrates R&D and manufacturing, and promotes the upgrading of Taiwanese industries, and (c) to improve links between technology generation and industrial diffusion of technologies.

4.2.1.3 "Two Trillion Twin stars" programme

Aiming to build Taiwan as a "green silicon island", the Taiwan government brought out a six-year national development plan in mid 2002. To fulfil that goal, in 2002, the MOEA ran a four-year "Two Trillion Twin stars" programme from 2002 to 2006. The programme will drive the production

value of Taiwan's relatively mature semiconductor and flat-panel display (TFT-LCD in particular) industries to NT$1 trillion (US$29.6 billion) for each – hence the term "Two Trillion". It also built the new digital content and biotechnology sectors into "star industries" – hence the name "Twin star". The 'Two Trillion' (semiconductor and flat-panel display) is already relatively mature, while the 'Twin star' (biotechnology and digital content) is new and full of potential.

According to Industrial Development Bureau, MoEA, the promotion of the "Two Trillion Twin stars" programme begins from offering tax rewards, assisting in solving obstacles to investment such as land, water, electricity, environmental protection, etc., integrating the government and industrial resources, developing new products and new technology, establishing the complete upstream and downstream industry system, as well as talent training; and in these ways improving the competitiveness of the industry overall.

As for the industry development goals of "Two Trillion Twin stars", the hope is that the semiconductor industry can reach production values of NT$1.590 trillion, flat-panel display industries NT$1.370 trillion, the digital content industry NT$0.370 trillion, and the biotechnology industry NT$0.250 trillion in 2006

4.2.2 Demand side and infrastructures

4.2.2.1 Deregulation of telecommunications

Taiwan, in officially becoming a WTO member on January 1, 2002, aims to implement the accession commitments and continue forwarding telecommunications liberalization policies. The liberalization of telecommunications in Taiwan is an outgrowth of two policies, those regarding the Asia-Pacific Regional Operations Center and the National Information Infrastructure, and is opening up the island's telecommunications market through a staged progression. In the first step toward liberalization, the ownership of terminal equipment by subscribers was opened up in 1987. Later in 1989, the step taken was the opening of the market to value-added services so as to provide consumers with a diversity of such telecommunications services. The passage of three telecoms-related laws in 1996 led to the formal separation of the Directorate General of Telecommunications (DGT), which is in charge of telecommunications industry regulation, and the Chunghwa Telecom Co., which is responsible for operating the telecoms business. This separation more firmly established the policy directions for liberalization, and later further liberalization steps were taken particularly in services of mobile telecommunications and satellite telecommunications.

After 1999, liberalization has continued in various fields of services, such as integrated fixed network telecommunications, international submarine cable leased-circuit, local and long-distance leased-circuit cable, resale business, and third-generation mobile telecommunications (3G). The

short-term objective of telecom liberalization is thus completed. After releasing 3G mobile telecommunication business to the public in 2002, the government released all telecommunication business and Taiwan's telecom market has move into full liberalization.

In addition, in order to cooperate with the implementation of the "e-Taiwan Project" in Executive Yuan's "Challenge 2008 – National Development Plan", the DGT of Ministry of Transportation and Communications also plans broadband networks construction indexes (Table 6).

Table 6

Broadband Networks Construction Evaluation Index

	2002	2003	2004	2005	2006	2007
Domestic north-south backbone network bandwidth (Gbps)	850	950	1050	1150	1200	1250
International backbone network bandwidth (Gbps)	150	200	200	200	250	250
Fiber-to-the-Cabinet (FTTC) covering rate (%)	82.0	85.5	88.5	91.0	93.0	95.0
Ratio of broadband population (%)	25	40	50	60	65	70
Broadband population (10,000 person)	200	300	380	460	530	600

Source: Directorate General of Telecommunications (DGT)

In general, telecommunications liberalization policy in Taiwan has introduced competition mechanisms successfully, revitalizing the telecommunications industry structure and leading to the effective growth of telecommunications business. However the ratio of telecommunications revenues to GDP, though gradually increasing, is still below the world average of 3.4%, indicating that the domestic telecommunications market is not yet fully expanded.

4.2.2.2 Policies for encouraging demand (E-Taiwan, M-Taiwan)

1. E-Taiwan: March on with a new vision

To embrace the global e-trend and confront all the challenges that cloud the future of Taiwan's IT industry – the impact of the global knowledge-based economy, outward-moving business and decreasing total revenues, etc. – the Convenor of NICI (National Information & Communication Initiative) of the Executive Yuan, working with many chief officers from other government agencies, leading academies, research institutions, top enterprises and civil organizations, has formulated the "e-Taiwan program" to counter all these issues.

The "e-Taiwan program" was formally approved by the Executive Yuan in June 2002 and combined with nine other plans to form the so-called "Challenge 2008: the 6-Year National

Development Plan". Not to overstate its importance, the "e-Taiwan Program" holds the key to the complete success of "Challenge 2008". There are five integral parts in this plan, i.e. "6 million broadband users", "e-Society", "e-Industry", "e-Government" and "e-Opportunity". "6 million broadband users" is expected to deliver the following results by 2007: (1) broadband network is fully installed with implementation of IPv6 and wireless LAN environment, (2) small & medium enterprises are mostly brought online, (3) safety standards, regulation, strategy and legislation are properly installed and in full operation, (4) IC security enforcement is strictly observed and capable of fostering the related industries, (5) CA cards have been successfully issued and commonly accepted as a primary means of identification.

2. M-Taiwan(FIND, 2005)

The third IT revolution aims to forge the personal computers, internet and mobile communications into a *"Ubiquitous Network"*. By utilizing this network, the government, entrepreneurs and end-users are able to get the information they need by any device, at any time and anywhere – more efficiently, more conveniently, and giving better quality of life.

With the advantages of the world's No.1 production value of WLAN products and mobile phone penetration rates, the Taiwan government has actively promoted Mobile-competitiveness. The National Information and Communication Initiative (NICI) committee of Executive Yuan (Cabinet), Ministry of the Interior (MOI) and Ministry of Economic Affairs (MOEA) coordinated to propose the "M-Taiwan Program" with a budget of NT$37 billion in five years. The M-Taiwan Program is expected to build up the wireless networks, integrate mobile phone networks, set up optical-fibre backbones, and execute the Integrated Beyond 3rd Generation (iB3G) Double Network Integration Plan. It is also expected to shift Taiwan from an 'e-nation' to an 'm-nation', and to reach the vision of "Mobile Taiwan, infinite application, and a brave new mobile world". Regarding the objectives of M-Taiwan program, see Appendix 6.

4.3 Mode of Governance

4.3.1 Governance for Business – moving to ODM

Since the 1970s when foreign-owned firms started to invest in Taiwan, many Taiwanese manufacturers became their original equipment manufacturer (OEM). Since the 1980s when production of the first personal computers began, under the open system policy of IBM, some Taiwanese manufacturers produced IBM-compatible computers with their own brands, such as Multitech by Acer (renamed in 1987). Since then, the percentage of Taiwanese manufacturers producing products with their own brands has increased only slightly.

As observed by Huang (1995), since 1989 when the US economy was in recession, the growth rate

of sales for Taiwanese computers with their own brand in the US market decreased almost to zero. Especially in June 1992, when Compaq announced reduced prices of its all series products by up to 30-40%, branded computer manufacturers in Taiwan were forced to give up their own brands. However, at the same time, many European and American computer enterprises started to look for the OEM that was able to control production costs efficiently. Thus, Taiwanese computer manufacturers returned to the mainstream computer market by the way of the foundry. At the same time, Acer also announced it was giving up its own brand and becoming the OEM again. This indicated that, before the 1990s, the competitiveness of Taiwanese manufacturers was already recognized in terms of vertical specialization and internal management.

Since then, Taiwanese manufacturers have started to globalize and conduct direct investment in Southeast Asia and China. By exporting intermediate goods, equipment, technology and management knowledge to the Asia-Pacific area, Taiwanese enterprises started to export final goods to the global market. On the other hand, Taiwanese enterprises also put their resources into product design and became ODMs. In addition, since the middle 1990s, some big manufacturers with famous computer brand names such as Dell and Compaq, started to utilize a strategy of **"built-to-order"** which meant that, under their logistic information systems, customers could place an order and receive products directly from various global locations (Wu et al., 2002).

In summary, Taiwan's manufacturers have tried to transform themselves from traditional Original Equipment Manufacturing (OEM) providers into Original Design Manufacturing (ODM) providers and Collaborative Design Manufacturing (CDM) providers, while working to strengthen collaborative design R&D management capability.

4.3.2 Governance for Government

In the early stage, the flow of knowledge or competence building came through the way international companies invested in Taiwan. Afterwards, the Taiwanese government actively promoted the establishment of research institutions, not only introducing advanced technology and knowledge but also researching and developing by themselves, and then transferring technology from abroad, setting up spin-off companies, or floating talents; in these ways spreading knowledge and technology to the whole of industry little by little. The industries begin to establish good connections with Hsinchu Science Park and Silicon Valley at the same time.

In relevant governmental policies, the establishment of the Science Park and the ABCDE plan have both been quite successful, with an important influence on the industries. However these comparatively successful plans are mostly an extension of past achievements in manufacturing and design. In addition, the liberalization of the telecommunication market has been quite successful, especially for wireless communication; nevertheless, relevant results still need to be observed.

After the industries gradually set up their R&D competences, the great progress in industrial technology means the whole innovative system has to be adjusted; for example, the research institution must transform its roles, the function of universities must be improved and so forth. Actually, the Taiwanese government has put more effort in this direction in recent years.

5. Overview of the ICT Sector

5.1 The ICT evolution from a Historical Perspective

The development of the ICT industry / society can be divided into three stages generally (Figure 3: Huang, 2005): The first stage (1979-1989) was the "IT Awareness Promotion", which mainly popularized the idea and application of information. Therefore, in IT talents training, III (Institute for the Information Industry) cooperated with the National Youth Commission of Executive Yuan to run various kinds of educational training, such as developing the professional information ability of those people without an IT background. At this stage, regarding the ICT industry, III developed the Chinese computer in 1983 in order to popularize the application of information technology. Besides, III formulated the Chinese ICT Standards in order to popularize the utilization of a Chinese-environment system for PCs. These measures were established as the most important foundation of the Taiwan's informatization. Besides, in 1988, supported by the MOEA, III started the SEED Plan (Software Engineering Environment Development) for a duration of 4 years, whose main purpose was to create a Seed Net based on the internet. This was the first to adopt a TCP/IP internet communication agreement in the country before telecom liberalization; at the same time, it was free for enterprises to apply for open connecting software for a Chinese work environment, which promoted internet business applications in Taiwan (Ke 2005). As for the social aspect of ICTs, III set up the first banking information system and ran the "Information Month" activity; the scale and content have increased year by year up to now.

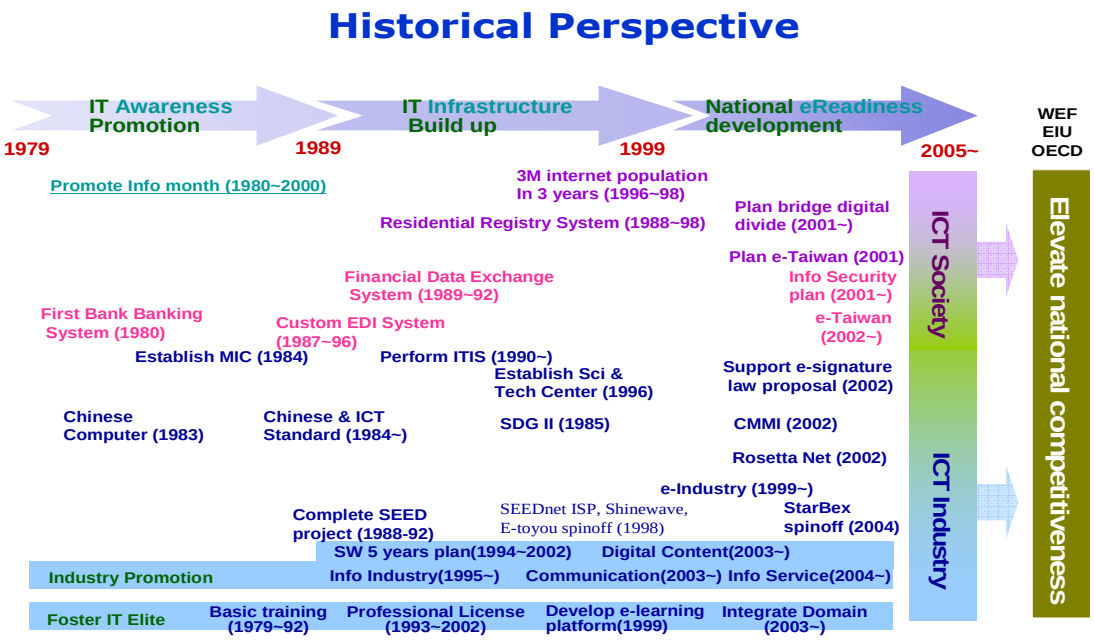
The second stage (1989-1999) was that of "IT Infrastructure Building up". III was mainly to promote professional certificates and set up e-learning platforms in IT talent training. Taking the budding of internet business applications in 1996 to be a start, the Executive Yuan established the National Information Infrastructure (NII) and promoted projects of e-competitiveness. With respect to ICT promotion, the Ministry of Transportation and Communications announced liberalization of fixed network telecom industry in 1997, the Ministry of Finance liberalized online banking and online inter-bank transfers began, and besides, Chunghwa Telecom launched a DSL service in 1999. From 1996 to 1998, Taiwan reached the landmark of "Three Million Onlines in Three Years", which laid the foundation of flourishing internet development.

The third stage (1999-2005) is that of "National eReadiness Development". IT talent training included not only the e-learning platform as at the second stage but also the plan of cultivating ICT talents in integrating relevant fields. In relation to ICT society, from 2001 to now, III assisted the

government to propose a blueprint of Digital Taiwan, which is expected to take e-experience from urban areas to rural areas, from corporations to small businesses, from the hinterland to the world. In addition, III set up the safe mechanism plan of information infrastructure in 2001, promoted the "Law of e-Signature" in 2002, and planned the "e-Taiwan Program", focused on accelerating the establishment of a digital society and leading Taiwan to become one of the most advanced e-nations in Asia.

Figure 3

Historical timeline of ICT development n Taiwan



5.2 The Input of ICT

R&D investments in high-tech manufacturing industry accounts for 70.6% of all R&D investment, higher than all other main countries; this rate was 50.1% in 1995. In R&D investment by high-tech industry, office, accounting & computing machinery is 20.8% and television & communication equipment 45.4%, which are related to ICT, account for 66.2% of the total.

Table 7

R&D Expenditure and Personnel in the ICT Industry, 1999-2004

Year	R&D Expenditure (Million NT$)	Percentage of BERD	R&D Personnel		R&D Researchers	
			Headcount	FTE	Headcount	FTE
1999	72,128	59.0%	43,867	36,861	22,163	20,358
2000	78,483	62.4%	49,107	40,484	24,044	21,858
2001	85,893	65.9%	51,069	43,034	26,609	24,992
2002	94,914	68.0%	57,328	46,789	30,265	27,157
2003	104,555	69.5%	63,882	51,895	32,940	30,002
2004	118,032	70.3%	69,421	57,686	36,410	33,385

Source: Indicators of Science and Technology (Table 2-2-7), Republic of China, 2005
Note: The range of ICT is based on the definition of the OECD Frascati Manual, 2002; FTE= Full-Time Equivalents.

Table 7 shows that the R&D investment of domestic industries mostly centres on the ICT industry; the proportion of ICT R&D expenditures to whole-enterprise innovation expenditure reached 70.3% in 2004. However, the density of R&D investment in Taiwan's high-tech manufacturing and ICT industries is relatively lower than other countries. This phenomenon may be related to the operational mode of Taiwan's ICT industry, mostly OEM/ODM; though the operational scale of ICT-relevant industries is quite large, innovation investment is still relatively low.

5.3 The Dynamics of the ICT Industry and its Exports Trend

In the information electronics field, the industries of "Electronic Parts & Components" and "Electrical Machinery, Supplies & Equipment & Repairing" grew very fast; on the contrary, the industries of "Computer, Communication & Video & Radio Electronic Products" transferred from growth to decline. In Taiwan, Electronic Components is the most competitive industry in terms of exports.

5.3.1 Output: industrial trends and export competitiveness

The export proportion of high-tech industry accounts for approximately 42-45% of all manufacturing industry (Table 8); however, the export proportion of computer-relevant products has dropped year by year in recent years. This phenomenon has partly to do with "the fast decline of product cost" caused by the operation pattern of "accepting orders in Taiwan and manufacturing abroad" and influenced by the global competitive environment.

Table 8

Export shares of High-tech Industry, 1996-2004

%	1996	1997	1998	1999	2000	2001	2002	2003	2004

Manufacturing	100	100	100	100	100	100	100	100	100
High tech	**34.28**	**36.51**	**38.94**	**41.84**	**45.46**	**43.20**	**43.18**	**43.03**	**42.53**
…Pharmaceuticals	0.20	0.19	0.18	0.17	0.12	0.13	0.13	0.13	0.13
…Office, Accounting and Computing Machinery	16.57	18.27	20.06	20.57	19.88	19.72	18.14	14.64	11.24
….Radio, Television and Communication Equipment	15.45	15.90	16.51	18.64	22.61	20.52	21.28	22.89	24.27
….Medical, Precision and Optical Instruments	2.06	2.14	2.16	2.42	2.77	2.73	3.55	5.30	6.82
… Aircraft and Spacecraft	0.00	0.01	0.03	0.04	0.08	0.11	0.07	0.06	0.07

Source: Export/Import data tape of R.O.C. 2004, calculated by TIER

5.3 Demand side of ICT

5.3.1 The Infrastructure of ICT

"Challenge 2008 – National Development Plan" was launched in 2002, by means of strategic actions of e-government, e-industry, and internet society, and which were enlarged through informational applications for each department and informational education training. Those above had great help in improving the information environment and web services in Taiwan. Internet services could be divided into three parts: government, business and personnel. The important achievements included setting up a government service web (GSN), a government certification mechanism, an official e-document exchange, an e-government service platform, e-government portal, governmental website contents, thousands of official application forms, and several new government e-services including G2G, G2B and G2C. Although the internet services and applications in enterprise were mainly supported by business itself, the government also provides essential support, including "Projects A, B, C, D, and E"; "Demonstrated IT Application Research Program", and "Technology Research Program for Innovative Services". Most of the support by government involved integrating standards from industries, developing job application platforms, and setting demonstrative applications, which amplified the leverage effects for industry.

5.3.1.1 Broadband Infrastructure

Broadband construction in Taiwan is divided into fixed line and wireless. For the fixed line, the main development plan is the "*6 million broadband users*" of e-Taiwan. The annual goals of this plan are set out in Table 9. In order to promote the application and development of wireless broadband, the 2nd stage (five-year plan) of the "National Science and Technology Program for Telecommunications" provided by NSC and the "M-Taiwan Plan" proposed by the MOEA, the government might provide help. NSC expect to develop new relevant techniques by 2008, by doing so, the users could surf among WLAN, GPRS and 3G; it could let at least 600,000 people have the convenience of internet surfing and of using web phones to connect in an environment of wireless networking. Besides, the goal of the "M-Taiwan Program" was to promote a ubiquitous network

and e-services in Taiwan.

Table 9
The planning of Internet Construction in Taiwan, 2002-07

	2002	2003	2004	2005	2006	2007
North-South Basebone for Island wide (Gbps)	850	950	1050	1150	1200	1250
International connection cable (Gbps)	150	200	200	200	250	250
FTTC fixed line area fibre coverage rate (%)	82.0	85.5	88.5	91.0	93.0	95.0
Broadband subscribers (10 thousand)	205	300	380	460	530	600

Source: Fan (2005)

5.3.1.2 Information and telecommunication security

In January 2001, the Executive Yuan set up the Contingency Centre of National Information and Communication which is in charge of ICT infrastructure security and passed the *"National Information and Communication Infrastructure Security Mechanism Plan"*. Besides, the plan of "*6 million broadband users*" has a subordinate plan, "Setting up an ICT security environment". The government still activated other information security programmes:

1. *Public Key Infrastructure（PKI)*: set up a "Promotion Task Force" to promote a citizen's digital certificate program, corporation certificate program, medical certificate program, etc.
2. planned and set up government information exchange safety standards
3. implemented related laws
4. information safety technique research

5.3.2 The current status of the Information Society in Taiwan

After cultivating IT for so many years, Taiwan has made great progress in informational social readiness, as shown in education, R&D quality and internet penetration rate (Table 10). As for the internet connection can be divided into 3 segments: home, business, and government (Table 11)：

Table 10

Status of Education, R&D, and Internet Application in Taiwan, 1996-2004

	Unit	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gross enrolment rate of higher education (18-21)	%	NA	NA	56.1	31.0	68.4	77.1	83.4	90.2	---
Literacy rate for over age 15	%	94.3	94.7	94.9	95.3	95.6	95.8	96.0	97.0	---
R&D Personnel	10,000	11.7	12.9	12.9	13.5	13.8	13.8	15.0	15.7	16.9
R&D/GDP	%	1.80	1.88	1.97	2.06	2.06	2.17	2.21	2.45	2.54
Internet user	10,000	60	166	301	480	627	782	859	883	916
Internet penetration rate	%	3	8	14	22	28	35	38	39	40
Broadband internet user	10,000	---	---	---	2	23	114	213	289	360
Mobile internet user	10,000	---	---	---	---	---	28	155	350	535

Source: Ke (2005: 29)

Note: 1. Broadband Internet users include xDSL, Cable Modem, Fixed Line with Fibre Connection

2. Mobile Internet users include WAP, GPRS, PHS or 3G

Table 11

Internet Connections of Taiwanese Homes, Business and Government, 2001-04

		2001	2002	2003	2004
e-Government	Government agencies broadband penetration rate	–	78%	100%	100%
	Government agencies website penetration rate	–	---	85%	85%
	Government agencies online	–	100%	100%	100%
e-Business	Corporate broadband penetration rate	–	80%	90%	96%
	Corporate website penetration rate	–	22%	27%	36%
	Corporate Internet penetration rate	44%	62%	79%	81%
e-Home	Home PC penetration rate	–	72%	71%	73%
	Home Internet Penetration rate	39%	53%	57%	61%
	Home Broadband Penetration rate	40%	58%	73%	78%

Source: Ke, 2005:30

5.3.4 The Performance of the ICT Industry (NSC, 2005)

The World Economic Forum (WEF) published the *Global Information Technology Report 2005-2006*, in which Taiwan ranked 7th in the Networked Readiness Index (NRI) out of 115 economies, representing an impressive improvement over the 15th place ranking achieved in 2004. In terms of all three dimensions, Taiwan ranked among the top ten worldwide, placed fifth for Usage Index, eighth for Readiness and tenth for Environment. Among the three main sub-indices covered in each dimension, Taiwan performed particularly well in Market Environment (3rd), Individual Readiness (4th) and Government Usage (4th). One mistake in the country profile for Taiwan has been confirmed by the WEF: The real ranking for the 'Cable modem Internet subscribers' variable for 2005-2006 should be 19th rather than 68th.

According to the "National Science and Technology Program Implementation Regulations" drafted and approved by NSC in 1998, as response to Taiwan's major socioeconomic and employment needs, and in order to integrate up-, mid- and downstream R&D resources, there are three programmes related to ICT, respectively Telecommunications, Digital Archives, and e-Learning.

1. The National Sci-Tech Program for Telecommunications was being implemented during the years of 1998-2003 and 2004-2008 with total funding of NT$ 12.36 and 13.35 billion. Apart from the first phase's areas of wireless communications and broadband internet, the second phase has added the category of application services in an effort to establish a full range of telecommunication systems technologies.

2. The National Sci-Tech Program for Digital Archives was being implemented during 2002-2005 with total funding of NT$ 2.78 billion. The primary goals of this programme contain the digitization of the nation's important artifacts and collections, and the use of a national digital archive to promote cultural, social, industrial and economic development.

3. The National Sci-Tech Program for e-Learning is being implemented during 2003-2007 with total funding of NT$ 4.01 billion. The programme's goals are to increase citizens' opportunities for lifelong study, promote the development of e-learning industries, and encourage academic research on e-learning. This programme also emphasizes social goals such as the promotion of e-learning at the level of citizens and bridging the digital divide in Taiwan, as well as infrastructure support through the Network Science Park for e-learning.

6. Policy Implications

After reviewing the policies and related performance of the past ten years, we might conclude that those polices played a role in supporting industry to follow the trends, especially the ABCDE program and TDP program. TDP in research institutes also helped industries to follow the emerging technological trends of ICT. The ABCDE program helped the firms to connect more closely between Taiwan and international branding companies as well as between upstream and downstream ICT companies in Taiwan. This helped the OEM/ODM business model in which Taiwanese firms became more competitive than other areas.

Besides manufacturing, the performance of product design has also shown some major achievements in international awards. When we reviewed the cases of companies and policies, we found that it was mainly because the capabilities were built up through two national awards (SOE and NAOE, since 1989) as well as the impact from Acer. Both awards awoke companies in

traditional industrial sectors to realize the importance of quality and product design and started to build up the capabilities. Then, when the ICT-related companies found that they were in a highly homogeneous product market, they invited experts in traditional industrial sectors to help and combined their product design into manufacturing processes.

As for the demand side of ICT policies, we could see the impact of deregulation of the wireless service sector in the highest density of cellular mobile telephones in the world. However, the effect of other policies, like e-Taiwan and M-Taiwan, has not yet appeared in any macro indicators, nor in the share of communication services in GDP. That means the demand side policies still need to be monitored.

6.1 Review of Taiwan's ICT: policy problems

6.1.1 The value-added rate of Taiwan ICT industry is at a low ebb

Because Taiwan's ICT manufacturing industry (computers and OA equipment; electronics and communication equipment; precision, optical, and medical equipment) has a high degree of division of labour, the supply of information and electronic products exceeds its demand and prices have plunged. In addition, Taiwan's ICT industry is restrained by large MNC plants and threatened by catching-up countries; therefore, the added value is lower than for advanced country on the one side, and for South Korea too on the other side.

6.1.2 Domestic large plants concentrate on the OEM stage of lower value-added

Different innovative patterns and the degrees of integration of value chain activity influence the profit rates of enterprises. The operations patterns of MNC large plants in ICT, like Microsoft, Intel or Nokia, contain many value-adding activities: R&D, design, engineering, manufacturing, logistics, marketing, sales and service, and so on. R&D intensity exceeds 13.5%, and the operating profit margin reaches 17-40%. Taiwan's IC big plants such as USMC, UMC, Media Tek, etc., are deeply committed to R&D and integrated with services; the operating profit margin also advances. In comparison, the Taiwanese IT system contract manufacturer focuses on the subcontract production mode where the rewards are lowest in value; the R&D intensity and investment are relatively low, and the gross profit rate and operating profit margin are relatively low as well.

6.1.3 Lack of original and radical R&D

ICT OEM enterprises mostly depend on the path of technology that the big international companies used. The depth of innovation is limited, which influences profit making. Because Taiwan's ICT industry relies mainly on international OEM, its R&D and the direction of product development chiefly follow the main technological structure established by large foreign companies: "the technology of mass production" and "cost control" are much more important than "the development of original products". Therefore, it is difficult to create new and obvious added value (Chen Xin-Hong et al, 2005). In addition, the result of an investigation in Taiwan (TIER, 2005) shows that

the reasons why enterprises spend time and money on R&D but are still unable to improve the performance of management are mostly because they have no cost advantage (18.4%), the product differentiation is insufficient for meeting the needs of the market (15.7%), it is not easy to raise prices for products which are controlled by buyers (big foreign companies), and they fail to catch the most appropriate time to market (13.9%). These factors reflect that domestic ICT industries are concentrated on OEM, the scale of enterprises is too small and the homogeneity is too high. When facing the lack of bargaining chips of negotiation with large international companies and the threat of replacement by catching-up country rivals, enterprises lean towards price competition, the pursuit of low defect rates, the advantages of production cost, and winning through quantity; these enterprises neglect establishing the diversity competencies of originality and uniqueness so that profits become lower and lower.

6.2 Policy suggestions

In industrial policy, Mainland China has influenced demands in the local market for establishing infrastructure, drawing up technical standards (such as digital TV, TD-SCDMA, WAPI), installation fees and user fees for telecommunications (fixed line and mobile phones) and adjustments of household registration policy, etc., in order to support domestic manufacturers and negotiate with multinational plants. Meanwhile, on the one hand, the Government utilizes permissions to operate, the certification system, concessions for foreign investment, etc., in cooperation with policies of foreign exchange control, quotas on domestic sales and so on, to lead the local plants of MNCs to expand their local production scale continuously; on the other, it utilizes the cluster effect of local assembly industries to encourage the component industry to move in progressively by means of tax credits, proportions of domestic purchase, alternative tariffs, etc. Therefore, industrial policies play an important role in the development of ICT.

Freer and more open attitudes are necessary for Taiwan nowadays: First, the Government should cancel unnecessary restrictions on talent, funding and transportation in terms of the total planning of relevant preferential policies, actively introduce foreign technicians, and then open three direct cross-Strait links with moderate financial liberalization; these measures will encourage domestic and international enterprises to utilize Taiwan's natural advantage of the Asian-Pacific Operation Centre to attract global resources and continuously improve the competitiveness of the industrial environment.

In terms of active measures, as for the communication industry which has entered Mainland markets extensively, an interview with III Adviser Chen Wen-Tang brought up the tactical thinking of *"letting bulls into the wild, training calves and entrapping cows"*; that is to say, when facing ICT downstream assembly manufacturers that consider factors of cost and market ("bulls" such as PC, Monitor, Notebook, cell phone, desktop, printer, scanner, keyboard, mouse, etc.), the Government

should take an attitude of open freedom, letting them advance on the Mainland and seizing the market there. The ICT midstream industry, which refers to key components manufacturers for the needs of the "bull industries" (such as LCD, IC, battery, LED, RF, etc.), the key point for cultivating the "calves industry" depends on governmental policies. At present, except for fields/industries stipulated in the Statutes for Industrial Upgrading, there are no clear specific fields/industries setting foresight values. These midstream industries are just like growing calves; one should plant a lot of pasture, and foster it actively. Accordingly, Taiwan's government should strategically encourage the development of core industries that suit Taiwan with preferential policies: such as encouraging and promoting R&D alliances and R&D service industries, providing high-quality information services, encouraging enterprises to develop toward R&D design, brand marketing and logistic services, etc., increasing its added-value, and keeping the "calves industry" in Taiwan. What the Taiwanese government recommends as "trapping" refers to the ICT upstream industry such as materials and equipment, which are much closer to encouraging foreign manufacturers or large domestic plants to set up R&D centres; in this way strengthening high-level R&D design.

As for the communication industry, seeing that Mainland China discourages Taiwan manufacturers from setting up factories there out of considerations of national defence, the Government should assist Taiwan manufacturers in developing new technological innovation and product integration ability, and grasping business opportunities of the telecommunication service industry by helping Taiwan manufacturers cooperate with indigenous manufacturers. As for the consumer electronic industry, with enormous assembly capability in Mainland China, Taiwan can make the best of a weak key component industry and grasp relevant market chances such as digital TV and DVD through supplying the raw materials.

Taiwan's own information industry has developed rapidly in recent years, becoming one of the main motive forces in its economic development and making up, in a timely way, for the industrial gap left by the out-migration of labour-intensive industries. This has facilitated the smooth readjustment and transformation of Taiwan's industrial structure and laid down a foundation for the development of the knowledge economy. Nevertheless, as said above, with the steady innovation of Internet technology and the deepening of applications of information, the ability to develop the knowledge economy can no longer be assessed on production value alone but must also take into consideration the influence of information application capability on overall national competitiveness.

7. The Offshore Situation for Taiwan's ICT/IT in Mainland China

7.1 The past, present and future of Taiwan IT manufacturers entering the west market

All the time the process of heading west (which here means the Mainland China market) for Taiwan IT manufacturers is "Deeds speak louder than words", in consideration of politics and the intervention of policies. Taiwan's information and electronic industries have been investing in China since 1990; the range of investment began with early production activities, marketing

activities after 1995 and then the fields of R&D. However, at present Taiwan has already become the largest source of trade deficit for Mainland China: 79.5% of the information hardware of Taiwan IT manufacturers was made in China and it involves more than 80% of the shipment value of Mainland China's information hardware.

This study, following a research paper of III (Kao 2006/3), will explore the background of the industry, the modes of investment and the driving factors, and then analyse the current situation of Taiwan IT manufacturers' production, marketing and R&D arrangements in China, in this way predicting some trends of future development.

1. Industrial background

1990-1995: In Taiwan's electronic information industry, the manufacturers of desktop PCs components (case, power, mouse, keyboard, etc.) with lower price and higher manpower demand, aiming at lowering production costs, engage in the layout of the production base in Mainland China in the early 1990s, being attracted by plentiful and cheap production elements of Mainland China and relevant investment preferences.

1996-2000: As the low price tendency of PC becomes more obvious day by day, manufacturers attempt to obtain economies of scale by large-scale factories in order to lower costs and compete with those who entered the market of South China beforehand; in this way making up for the inferiority of production costs as far as the latecomers are concerned. Meanwhile, under the political opposition of Taiwan and China, the Taiwanese government strongly recommends a "southwards policy", encouraging Taiwan IT manufacturers to invest in Southeast Asia

2001-2005: 1. The excessively optimistic sales forecast for the PC market in the first half of 2000 affects the large increase of stocks of mobile phone key components, the phenomenon of the dot.com bubble and the global IT market transforming from a growth period to a mature period. When facing the situation that the competition of prices of large international IT plants becomes progressively keener, in order to maintain space for profit-making, Taiwanese IT manufacturers who expanded production excessively in China launching price negotiations use the scale of order as chips on the one hand and on the other, retract the purchase right of components, discuss the scale and price of orders with the manufacturers of relevant components directly and then reduce the potential interests in ODM orders that Taiwan IT manufacturers accept, which greatly shrink the profit-making of Taiwan IT manufacturers. 2. At the same time, because there is not much space left for price competition, IT manufacturers give up the strategies of contesting industrial ability and the competition via low prices, and then turn to focus on the R&D and marketing activities of market segmentation. Some components manufacturers strengthen progressively the recourse to inputs of their own brand in a

situation where the profit-making space of ODM is limited. 3. In addition, after many international cases of merger and acquisition of local manufacturers in Mainland China, Taiwan's IT manufacturer BenQ merges with the department of mobile telephone of Siemens in 2005; through this encouraging the global market share of Taiwan mobile phone industry to rise over 30% from 10%, and then obtaining the relevant intellectual property rights and international distribution. Therefore, BenQ begins to have its own brand.

2. Investment patterns

1990-1995: In the early stage, because the scale of the market is not big in Mainland China and the management environment is strange, Taiwanese manufacturers of electronic information began production in ways like "the process of importing materials" according to the strategy of reducing production cost.

1996-2000: Though there are many limitations on investment in Mainland China, when faced with cheap elements of production, similar language and relatively complete system of industry, etc. many Taiwanese IT manufacturers turned to investing in factories there in the name of large shareholders through tax concessions. In addition, under the policy of foreign exchange control in Mainland China, in order to prevent too many funds from restrictive utilization, manufacturers engage in buying low and selling high for components and end products through trading companies in Hong Kong mostly, keeping a large number of profits to use overseas.

2001-2005: When facing the industrial policies in Mainland China (e.g. setting up factories in local areas, limitations on domestic sales proportions, requirements for domestic purchase) and the foreign exchange control, etc., in order to raise market share in the Chinese market, large MNC plants strongly ask Taiwanese IT manufacturers to raise shipment volumes from the Mainland, as the foundation of the internal marketing quota. On account of "customer requests", Taiwanese IT manufacturers increase the proportion of production in Mainland China by a wide margin. The thinking behind entering Mainland China for Taiwan's IT manufacturers changes from "reducing production cost" to "the requirements of customers" under the pressure of the market.

3. The patterns of division of labour

1996-2000: After 1995, Taiwanese IT manufacturers shift the base of production previously in Southeast Asia progressively to Mainland China. Therefore, the proportion of production in Mainland China rose from 14% in 1995 to 33% in 1999, but dropped to 31.3% in 2000. The products that Taiwan's IT industry increase in the ratio of production in Mainland China mainly come from PC peripheral equipment such as monitors, CD-ROMs, cases, SPS, etc.

2001-2005: As international IT manufacturers require Taiwanese manufacturers to increase shipment volumes from Mainland China after 2000, the proportion of production of Taiwan's IT industry rises from 31.3% in 2000 to 47.5% in 2002 and to 79.5% in 2005; however, the proportion of production in Taiwan falls from 49.1% in 2000 to 35.7% in 2002 and to as low as 6.8% in 2005. Among the ways in which Taiwanese IT manufacturers divide the labour on both sides according to the mode of production, we find:

1. Since 2000, desktop PC related components and peripheral equipments of relatively low price shift to products that are relatively capital- and technology-intensive such as LCD displays, notebook computers, mobile phones, LCMs and so on.

2. The division of labour shifts from "high & low level products" before 2000 to "test-production and mass production", which makes Taiwan's IT manufacturers increase the production rate substantially in Mainland China.

3. Tracing its cause, the situation has something to do with the Mainland Chinese government being asked to improve operating efficiency by Taiwanese IT manufacturers and follow Taiwan's experience to set up export processing zones and bonded factories, and by so doing improve import and export efficiency, and the inconvenient contact of R&D personnel on the two sides.

4. Geographical distribution

1990-1995: After Mainland China opens to reform, the Government uses relevant industry policies, such as the huge "domestic- demand market" as a bait with foreign exchange control and the proportional limitation on domestic sales in order to attract manufacturers to set up their factory there. Because of the undeveloped infrastructure and high transportation charges in Mainland China, most international enterprises set up their factories in the coastal areas (such as Shenzhen in South China) and meanwhile utilize the cheap essential factor of production in Mainland China and the international freight transport and financial function in Hong Kong.

1996-2000:Because the scale of investment is very large, in order to reduce operating risk and focus on the expansion of the local market in future, the PC peripheral manufacturers choose the East-China area where public security is good, China's central government gives strong support, the government regulations are clearer and the geographical position is moderate.

2001-2005: The effect of early or late steps of economic opening to the outside world in different regions and characteristics of the varied industries in North, East and South part of the Mainland China.

1. North China area: Because the North China area is near the core of political power, it

attracts international communications manufacturers which are closely related to national defence security and manufacturers of local desktop PCs which have to strive for government resources (including orders and funds). Except for Acer and DBTEL, there are few Taiwan manufacturers (like mobile-phone components) which cooperate with *Motorola*

2. East China area: In the East China area, the regulations and management environment are relatively clear. Besides, the geographical position benefits the logistics of each domestic region in the domestic-demand market, and the actions to attract business investment are positive, so those latecoming IT and wireless communication manufacturers which have a large scale of investment and focus on the local market are attracted to enter this area. The production bases of Taiwan's LCD display, notebook computer, mobile phone, LCM and semiconductor manufacturers are mostly concentrated here.

3. South China area: Because the South China area is opened to the outside world early and the management environment is flexible, this area attracts numerous desktop PC manufacturers and consumer electronic manufacturers who regard lowering costs as necessary. Taiwan's industries related to desktop computers are mainly concentrated here.

5. Cluster patterns

1990-1995: For Taiwanese IT manufacturers who set up factories in the South China area, their ways of investment tend to be more conservative at the stage of testing the local management environment. In order to keep the present trading relationship and to exchange relevant industrial information, the industrial clusters are relatively concentrated and in addition, these manufacturers still maintain a cooperative relationship with Taiwanese manufacturers.

1996-2000: Taiwanese IT manufacturers who set up factories in East China area have two different types of cluster. The first is setting up factories in the local industrial area alone by their own efforts; they aim to persuade relevant manufacturers to set up factories in the East China area for nearby supply in order to improve purchasing efficiency, but will not require a cooperation relationship with the suppliers. The second type is of assembly manufacturers choosing a large amount of land to establish the large-scale industrial areas and then ask the suppliers to be with them, maintaining the supply relationship under a long-term cooperative commitment.

2001-2005: The scale of investment of Taiwan IT manufacturers becomes larger day by day and each local government in China solicits business positively under considerations of the development of the local economy and over-investment in industrial areas. They obtain a

large amount of industrial land through collective negotiation. The mode of 'group-exclusive industrial area' grows gradually.

6. Marketing arrangements

1990-1995: Because the scale of the Mainland IT market is still small, the investments of Taiwan IT manufacturers prefer the mode of "the process of importing materials"; therefore, most products are for sale overseas.

1996-2000: Because a high growth rate of 20%~30% appears in the Mainland PC market, some Taiwanese manufacturers already begin to accept ODM orders from the PC manufacturers in Mainland China. Though Taiwan's manufacturers strive for a proportion of domestic sales, they still focus on the international market while selling.

2001-2005: With the growth of the Mainland IT market, the proportion of products that Taiwan's IT manufacturers sell to Mainland China also rises year by year, from 5.2% in 2000 to 11% in 2004. In 2005, because the American and European markets were enjoying booms, the amount of high-priced products, such as notebook computers and mobile phones exported to Europe, USA, Latin America and Southeast Asia becomes large, so that the proportion that Taiwan's IT hardware manufacturers export to China falls to 7.4%.

7. R&D arrangements

1990-1995: Taiwanese manufacturers focus on production activities in the initial stage; and are rarely involved in the activities of marketing and R&D.

1996-2000: With the rising familiarity with the local environment and talent, Taiwanese IT manufacturers begin to realize that if they move partial R&D activities to Mainland China, they can employ local project personnel who have basic science and engineering training with cheap wages, thus reducing manufacturing cost. In the early stage, Taiwan's IT manufacturers adopted a division of labour mode for high/low product levels between Taiwan and Mainland China, in other words, the activities of R&D design were maintained in Taiwan, and the developing activities of process technology stayed in Mainland China.

2001-2005: In consideration of costs and management, most Taiwanese IT manufacturers choose factory sites as the R&D centre; therefore most IT manufacturers distribute their factories across East and South China, only a few game and software manufacturers choose to set up factories in North China with fragmentary distribution. As the production rates of Taiwan's IT manufacturers rise substantially in Mainland China, the patterns of division of labour of manufacture shift to the labour-division mode of test- and mass-production after 2000. In a situation where the two sides suppress 'Three

> Direct Links' across the Taiwan Straits for political reasons, the R&D activities of Taiwanese IT manufacturers in Mainland China shift quickly from the stage of accessing mass production to the stage of product development. In this stage, Taiwanese engineers come and go on both sides of the Strait.

Among the largest-scale 500 foreign-capital enterprises for import and export in Mainland China in 2004, 249 were IT manufacturers, and 70 came from Taiwan; hence the proportion of Taiwan manufacturers was 28%. From the viewpoint of Taiwanese IT manufacturers' contributions in Mainland China in 2004, the scale of imports and exports reached US$ 112.3 billion: The export value was US$62 billion and import value US$50.3 billion; the total favourable balance was up to US$11.7 billion, which represented 23.3% of the import value. If we compare this with the same sample group of 2002, we find there were 37 manufacturers which were on the list for the first time, and 23 of them were listed first in the group. All the information shows that the production scale of Taiwanese IT manufacturers in Mainland China has a tendency to expand gradually.

At the same time, if we analyse 33 Taiwanese IT manufacturers listed on board in 2002 and 2004, we find that though the import value rose to US$18.9 billion, since the export value was US$30.1 billion, a US$3.89 billion of unfavourable balance (24.6% of the import value) has already shifted to US$7.28 billion of favourable balance (20.9% of the import value), which shows that according to the trend where large MNC plants ask Taiwan IT manufacturers to raise production proportions in Mainland China, the orders for export which originally created foreign exchange for Taiwan have already been quickly transferred to China.

The degree of dependence on Taiwan's exportation to China had reached 37.23% by 2004, and the trade surplus exceeded $50 billion. The estimated amount of Taiwan's investment in China is more than US$50 billion, which is more than 40% of Taiwan's total foreign investments.

While the export dependence of Taiwan on China is getting deeper than before on the one hand, the import dependence of China on Taiwan is decreasing on the other hand (Table 12). For the Taiwanese electronic components industry in particular, the export dependence was 52.8% in 2004, representing a 2.09 point increase over the previous year.

Table 12

Degree of import/export dependence between Taiwan and Mainland China

Degree of import/export dependence	Export dependence of Taiwan on China			Import dependence of China on Taiwan		
	2003	2004	+/ -	2003	2004	+/ -
The Economic System	34.27	37.21	2.94	11.96	11.54	-0.42
Electronic Components	50.67	52.76	2.09	21.48	22.57	1.09
Manufacture	34.47	37.42	2.95	12.63	12.44	-0.19
Electronic Equipment (Radio, TV & Communication)	13.06	13.88	0.82	8.56	7.31	-1.25

Source: Shen (2006/3) The Direction of Taiwan's Industrial Development under the Changing Global Economy and trade，IDB/MOEA

In 1995, the percentage of production in Taiwan for information hardware manufacturing still remained 75%, the percentage of investment in overseas production in Mainland China was 14%, and in other foreign countries (mainly in Southeast Asia) was 11%. In 2000, the percentage of production in Mainland China reached 31.3% and 19.6% in other foreign countries, and only 49.1% production was left in Taiwan. The percentage of Taiwan's information hardware industry production going abroad (especially to Mainland China) increased year by year, and reached 79.5% in China and 13.7% in other countries by 2005, with only 6.8% remaining in Taiwan (see Figures 4a and 4b).

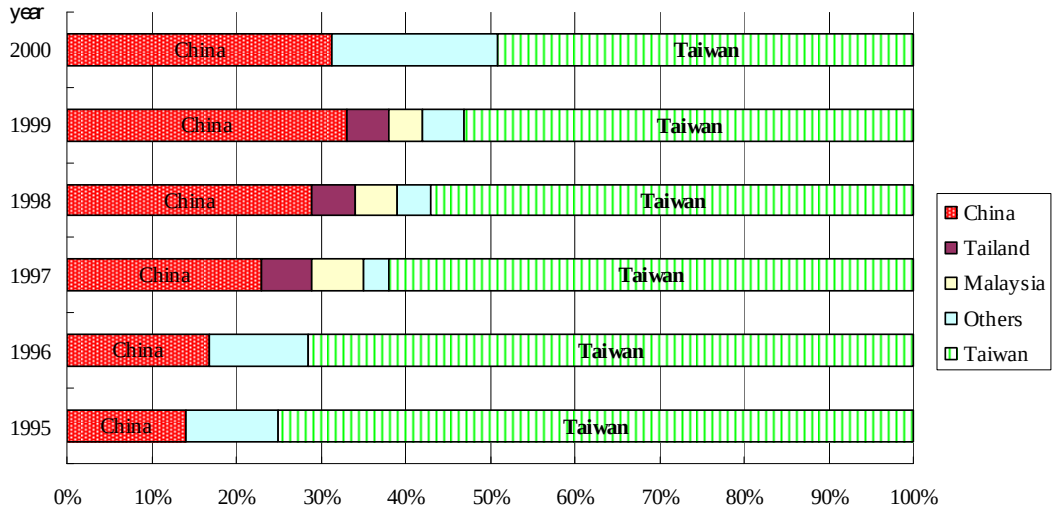
In 1999, the percentages of "power supply" and "casing" among the products of information hardware produced in Mainland China reached over 60%, "motherboard", "monitor" and "CD Rom/DVD Rom" were around 35%-45%. It is worth noting that the laptop PCs were mainly produced in Taiwan in 2000 (95.8%), however after that, the production percentage of laptop PCs in Mainland China rose rapidly to reach 94% by 2005. The also happened with other information hardware products. For instance, the percentage of "CD Rom/DVD Rom", and "Digital Camera" etc. produced in China was over 90%, and "motherboard" and "LCD monitor" also 80% (see Figures 7.5a and 7.5b). These two figures also show the transformation of information hardware products, with some products that show up in Figure 7.5a for 1996-2000 not appearing again in Figure 7.5b, such as LCD monitors, LCM, and digital cameras, etc.

To sum up, the impact of Mainland China on Taiwan's ICT sectors can be divided into four stages over the past 10 years: i) before 1997, mainly producing in Taiwan; ii) between 1997-2000, both Taiwan and Mainland China expanding; iii) between 2000-2002, expanding in Mainland China and keeping the same size in Taiwan; iv) after 2002, expanding in Mainland China and decreasing in

Taiwan.

Figure 4a

Overseas production by Taiwan's Information Hardware manufacturing, 1995-2000



Source: MIC, 2006/3

Figure 4b: Overseas production by Taiwan's Information Hardware manufacturing, 2000-2005

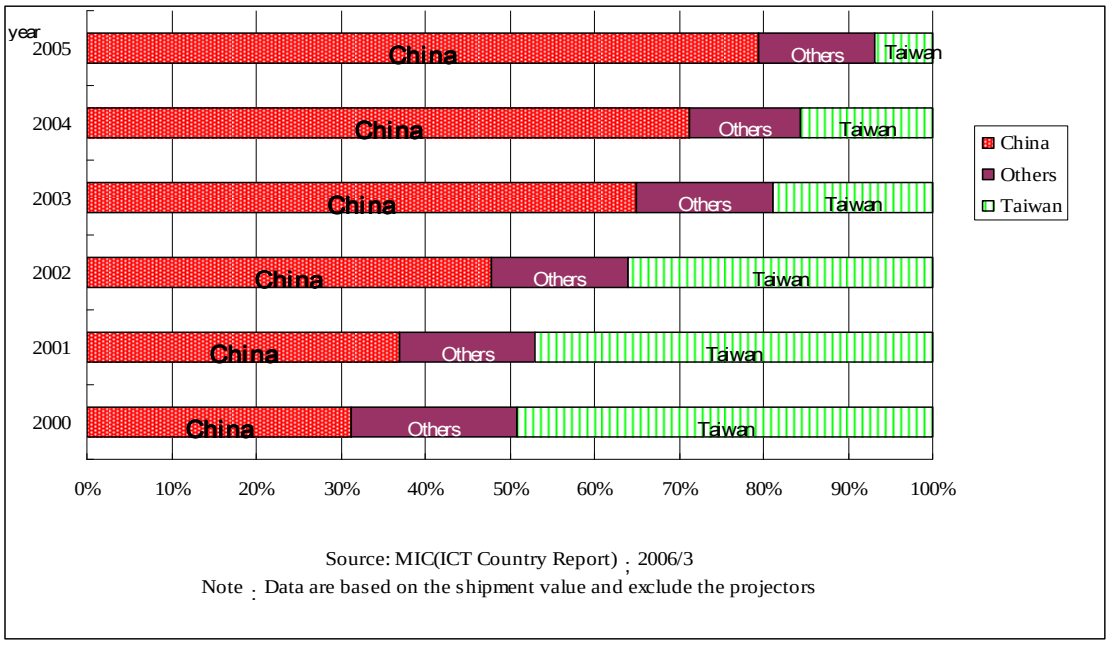


Figure 5a: Products produced overseas, 1996-2000

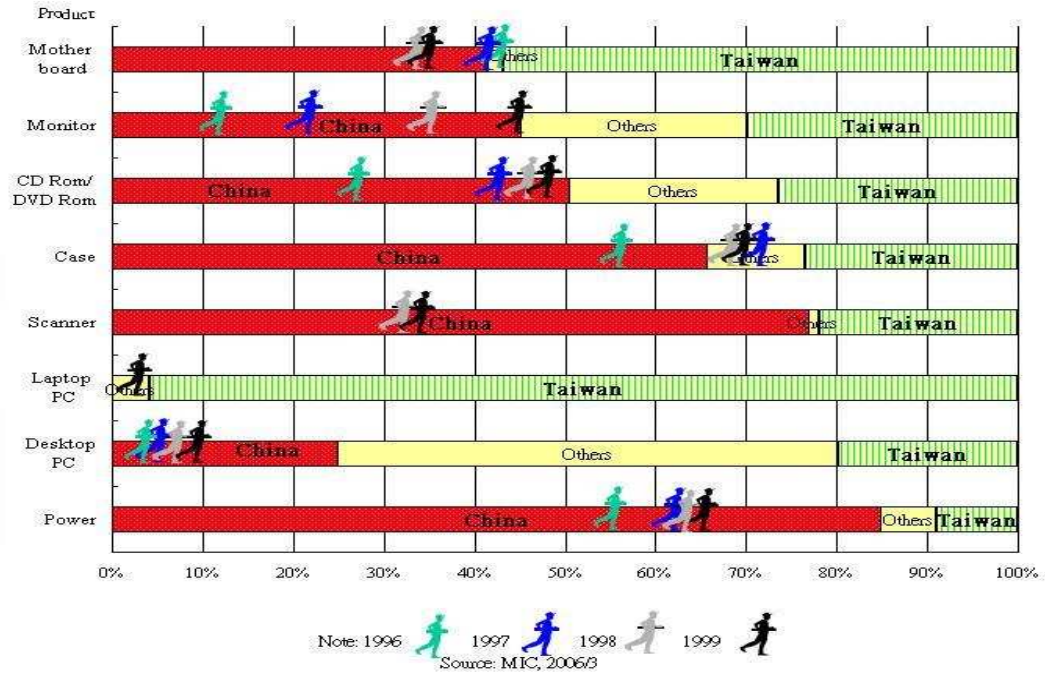
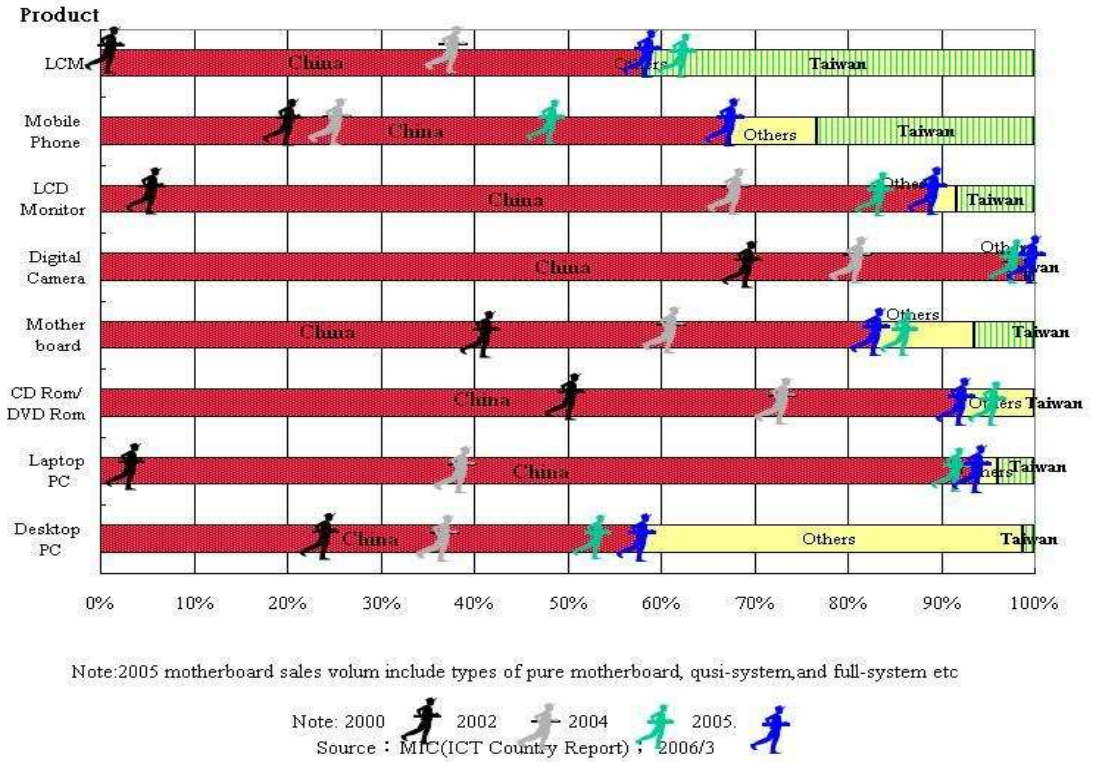


Figure5b: Products produced overseas, 2000-2005



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